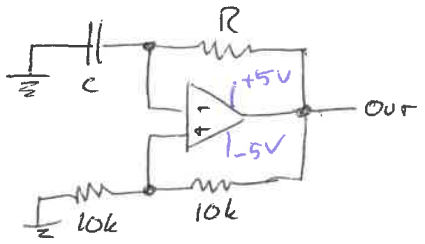
Problem 7.1



Switches at $\frac{1}{2}$ supply voltage

If $V_{out} = +5V$

then RC circuit charges and C charges

voltage divider will be at 2.5 V so will flip to -5 when V- goes to +2.5V.

when $V_{out} = -5$ voltage divider point = -2.5 so V_{out} flips when V- goes below -2.5V,

$V(t) = V_0(1 - e^{-\frac{t}{RC}})$

If $V(0) = 0$ and how long until $V(t) = \frac{V_0}{2}$

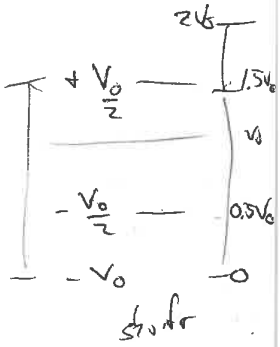
$\frac{V_0}{2} = V_0(1 - e^{-\frac{t}{RC}})$

$+\frac{1}{2} = +e^{-\frac{t}{RC}}$

$\ln\frac{1}{2} = -\frac{t}{RC}$

$t = 0.69RC$

Discharge $V(t) = V_0 e^{-\frac{t}{RC}}$

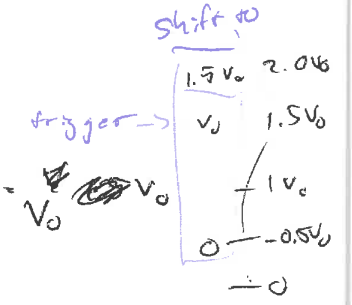


$V(t) = 1.5V_0 e^{-\frac{t}{RC}}$ how long until $V(t) = 0.5V_0$

$0.5V_0 = 1.5V_0 e^{-\frac{t}{RC}}$

$\frac{1}{3} = e^{-\frac{t}{RC}}$

$t = 1.1RC$ half cycle!



charging $V(t) = V_0(1 - e^{-\frac{t}{RC}})$ how long until $V(t) = V_0$

$V_0 = 1.5V_0(1 - e^{-\frac{t}{RC}})$

$\frac{2}{3} = 1 - e^{-\frac{t}{RC}}$

$\frac{1}{3} = e^{-\frac{t}{RC}}$

$t = 1.1RC$

Problem 7.2

when at +10 V, discharges towards ground through R_B

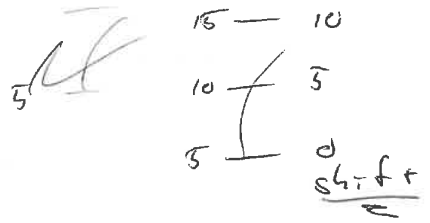
$V(t) = V_0 e^{-t/RC}$ until +5 when switches to positive

$5 = 10\, e^{-t/R_B C}$

$\frac{1}{2} = e^{-t/R_B C}$

$t = 0.693\, R_B C$

when charging from +5V towards 15 V, charges through R_A and R_B



$V(t) = V_0 (1 - e^{-t/RC})$

shift $5 = 10\left(1 - e^{-t/(R_A+R_B)C}\right)$

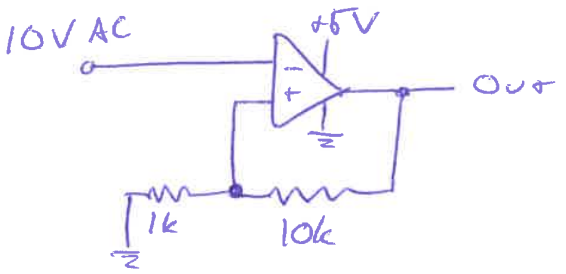
$\frac{1}{2} = 1 - e^{-t/(R_A+R_B)C}$

$t = 0.693\,(R_A + R_B)\,C$

so total period

$t = 0.693\,(R_A + 2R_B)\,C$

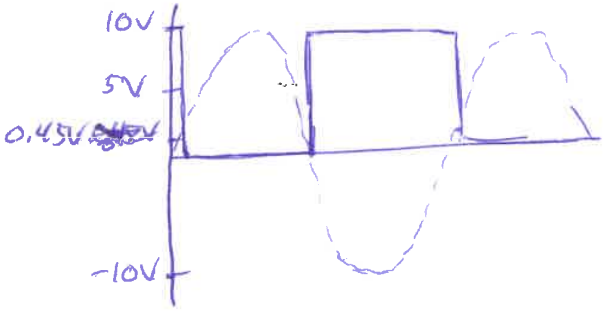
Comparators handout Problem 3



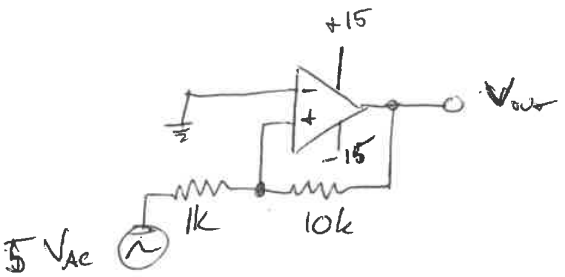
If $V_{out} = 5V$ then $V_+ = \frac{1}{11} 5 = 0.45V$

And V_{out} flips to 0V when V_- goes above 0.45V

If $V_{out} = 0V$ then $V_+ = 0V$ and flips to 5V when V_{in} goes ~~at~~ below 0V



Comparators handout problem 4



will flip when $V_+ = 0V$

If $V_{out} = 15V$, will flip when the input is at some negative voltage

so shift source to ground and add negative voltage to V_{out}

$V_{out} + V_{AC}$ ← shifted from negative

$V_+ = \frac{10}{11}(V_{out} + V_{AC}) + \frac{1}{11}V_{AC} = \left(V_{out} + V_{AC}\right)\left(\frac{1}{1+10}\right)$ ← shifted from zero

$0 + V_{AC} = \left(V_{out} + V_{AC}\right)\left(\frac{1}{1+10}\right)$

$V_{AC} = \frac{V_{out}}{11} + \frac{V_{AC}}{11}$

$\frac{10V_{AC}}{11} = \frac{V_{out}}{11}$ $\quad V_{out} = 15V$

$V_{AC} = \frac{V_{out}}{10} = 1.5V$ so flips at $-1.5V$

If $V_{out} = -15$ will flip at $+1.5V$

OR... Easier method

if $V_{out} = +15V$ will flip when $V_+ = 0$

$15 - I(10000) = 0$

$I = \frac{15}{10000}$ $\Rightarrow$ $0 - 1000I = V_{AC}$

$-\frac{15(1000)}{10000} = V_{AC} = -1.5V$

if $V_{out} = -15V$ will also flip when $V_+ = 0$

$0 - 10000I = -15$

$I = \frac{15}{10000}$ $\quad V_{AC} - 1000I = 0$

$V_{AC} = +1.5V$